



## NASA SBIR 2012 Phase I Solicitation

### H7.01 Ablative Thermal Protection Systems

Lead Center: ARC

Participating Center(s): GRC, JPL, JSC, LaRC

The technologies described below support the goal of developing higher performance ablative TPS materials for higher performance future Exploration missions. Developments are sought for ablative TPS materials and heat shield systems that exhibit maximum robustness, reliability and survivability while maintaining minimum mass requirements, and capable of enduring severe combined convective and radiative heating. In addition, in order to adequately test and design with these materials, advancements in instrumentation, inspection, and modeling of ablative TPS materials is also sought.

Areas of interest include improvements in the reinforcement materials as follows:

- Advancements in carbon felts including thickness ( $>1.0$ -in), density ( $>0.12$  g/cm<sup>3</sup>), uniformity to use as reinforcement for high strain-to-failure ablative TPS materials.
- Advancements in thin ( $\sim 0.1$ -in) three dimensional woven carbon materials to act as stress bearing structure for deployable aeroshells.
- Advancements in thick ( $>1.0$ -in) three dimensional woven carbon materials to use as reinforcement for high heat flux mid-to-high density ablative TPS materials.

TPS Materials advancements sought in felts or woven materials impregnated with polymers to improve ablation performance. Areas of interest include:

- One class of materials, for planetary aerocapture and entry for a rigid mid L/D (lift to drag ratio) shaped vehicle, will need to survive a dual heating exposure, with the first at heat fluxes of 400-500 W/cm<sup>2</sup> (primarily convective) and integrated heat loads of up to 55 kJ/cm<sup>2</sup>, and the second at heat fluxes of 100-200 W/cm<sup>2</sup> and integrated heat loads of up to 25 kJ/cm<sup>2</sup>. These materials or material systems must improve on the current state-of-the-art recession rates of 0.25 mm/s at heating rates of 200 W/cm<sup>2</sup> and pressures of 0.3 atm and improve on the state-of-the-art areal mass of 1.0 g/cm<sup>2</sup> required to maintain a bondline temperature below 250 °C
- The second class of materials, for planetary aerocapture and entry for a deployable aerodynamic

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decelerator, will need to survive a single or dual heating exposure, with the first (or single pulse) at heat fluxes of 50-150 W/cm<sup>2</sup> (primarily convective) and integrated heat loads of 10 kJ/cm<sup>2</sup> and the second at heat fluxes of 30-50 W/cm<sup>2</sup> and heat loads of 5 kJ/cm<sup>2</sup>. These materials may be either flexible or deployable.

- The third class of materials, for higher velocity (>11.5km/s) Earth return, will need to survive heat fluxes of 1500-2500 W/cm<sup>2</sup>, with radiation contributing up to 75% of that flux, and integrated heat loads from 75-150 kJ/cm<sup>2</sup>. These materials, or material systems must improve on the current state-of-the-art recession rates of 1.00 mm/s at heating rates of 2000 W/cm<sup>2</sup> and pressures of 0.3 atm and improve on the state-of-the-art areal mass of 4.0 g/cm<sup>2</sup>, required to maintain a bondline temperature below 250 °C.

Development of in-situ heat flux sensors, surface recession diagnostics, and in-depth or interface thermal response measurement devices for use on rigid and/or flexible ablative materials. In-situ heat flux sensors and surface recession diagnostics tools are needed for flight systems to provide better traceability from the modeling and design tools to actual performance. The resultant data will lead to higher fidelity design tools, risk reduction, decreased heat shield mass and increases in direct payload. The heat flux sensors should be accurate within 20%, surface recession diagnostic sensors should be accurate within 10%, and any temperature sensors should be accurate within 5% of actual values.

Non Destructive Evaluation (NDE) tools for evaluation of bondline and in-depth integrity for light weight rigid and/or flexible ablative materials. Non Destructive Evaluation (NDE) tools are sought to verify design requirements are met during manufacturing and assembly of the heat shield, e.g., verifying that anisotropic materials have been installed in their proper orientation, that the bondline as well as the TPS materials have the proper integrity and are free of voids or defects. Void and/or defect detection requirements will depend upon the materials being inspected. Typical internal void detection requirements are on the order of 6mm, and bondline defect detection requirements are on the order of 25.4mm by 25.4mm by the thickness of the adhesive.

Advances are sought in ablation modeling, including radiation, convection, gas surface interactions, pyrolysis, coking, and charring for low and mid-density fiber based (woven or felt) ablative materials. There is a specific need for improved models for low and mid density as well as multi-layered charring ablators (with different chemical composition in each layer). Consideration of the non-equilibrium states of the pyrolysis gases and the surface thermochemistry, as well as the potential to couple the resulting models to a computational fluid dynamics solver, should be included in the modeling efforts

Technology Readiness Levels (TRL) of 2-3 or higher are sought.

Potential NASA Customers include:

- Human Exploration and Operations Mission Directorate .
  - Multi Purpose Crewed Vehicle (MPCV) heatshield and backshell projects.
  - Asteroid Sample Return projects.
  - Future design of low Ballistic Coefficient entry vehicles using Hypersonic Inflatable Aerodynamic Decelerator (HIAD) or Adaptive Deployable Entry and Placement Technology (ADEPT) systems.
- Science Mission Directorate - Planetary Exploration Entry, Decent and Landing heatshield and backshell

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projects and Planetary Sample Return projects.

- NASA Commercial Orbital Transportation Services (COTS) projects.